# CONE SIX

# OXIDATION CLAY BODIES AND GLAZES

A Report

Presented to

the Faculty of the Graduate School

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A Requirement for the Degree

Master of Arts (Plan B)

by

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# PREFACE

Any individual endeavor, if it is to be a valuable and rewarding experience, must be governed by individual goals and initiated by a specifically defined purpose. My personal goals for graduate study were to develop greater skills and knowledge in ceramics through concentrated studio work and to increase my experience in all areas of artistic expression;—the ultimate purpose was to increase my effectiveness as a teacher in the public schools.

My decision to experiment with oxidation effects rather than reduction was influenced by personal needs as a high school art instructor. We do not use a fuel burning kiln in our school, so obviously we must work with ware produced in an electric kiln. At the present time, the kiln we use limits our firing range to that of earthenware, though it is my desire to have a kiln capable of firing to stoneware temperatures in the near future.

The purpose of this paper is to describe my studio experiments with cone six oxidation clay bodies and glazes, and to evaluate the results according to how they compare technically and aesthetically with those produced in a reducing atmosphere. This has been a personally satisfying study to me and I hope it will be of some benefit to others involved in the potter's craft.

I wish to express my sincere gratitude to the faculty of the Art Department at the University of Minnesota, Duluth for making possible the opportunity for graduate study over the 1972-73 school year. A special

acknowledgement is extended to Professor Glenn C. Nelson, my advisor and ceramics instructor, and to William Boyce, Head of the Department of Art, for their cooperation, encouragement and understanding.

# CHAPTER I

## BRIEF HISTORY OF GLAZES AND CLAY BODIES

The process of making pottery and glazes from materials obtained from the earth's crust is perhaps the oldest of all art forms. Today's technical knowledge of ceramic chemicals, availability of commercially produced materials, and modern firing techniques have made pottery, as an art form, available to all who desire to become involved. In order to fully appreciate the ceramic art, as we know it today, we must be aware of its historical development.

Being very resistant to the elements of nature, fired clay is one of the most durable of materials known to man. Hence, pottery or pottery fragments have been found which date back as early as 5000 B.C. Most of this ancient ceramic ware is attributed to the areas of ancient Egypt and the Middle East. There is no evidence of glazes being applied at this date, but the early potter used a technique called burnishing to make his ware functional in terms of being more impervious to water and more resistant to breakage. The body of these early wares was porous and crumbly due to low temperature firing in open pits.

The ancient Egyptians, to whom the first glazes are attributed, produced beads, ornaments and small sculptural pieces from talc (steatite), more commonly known as Egyptian Paste. Discovery of the glaze was likely accidental and the Egyptians soon made use of the abundant soda compounds found in the desert to make what are basically simple alkaline fluxed glazes. These early glaze compounds were mixed right into the clay body, but it was not long before they realized they could mix glazes separately, add color producing minerals, apply the mixture to the pot, and fire them much the same as we do today. With the use of alkaline fluxes and copper bearing minerals, the Egyptian glazes were usually bright blue or turquoise.

The discovery of the glaze was a great technical advancement for the potter, but the high alkaline glazes had many defects: they were not easy to apply, they had a tendency to peel off the ware with use, and they were quite soluble, making the pot unsuitable for cooking purposes. In the Mesopotamia area, these problems were overcome with the discovery of lead as a fluxing agent for glazes. They found that lead sulphide, or galena, when finely ground and dusted on the clay body would fire to a smooth, shiny surface. The lead glazes were simple to make, easy to apply and produced bright colors with the addition of metallic oxides such as copper, iron, and manganese.

The clay body used by the early Middle Eastern potters was a low fired earthenware, usually reddish in color and covered with a white slip which was often incised to expose the red body below. Buff, and even an almost white earthenware body was also used, but was quite gritty and porous. Although a true stoneware or porcelain body never developed in this area, perhaps due to the lack of kaolin deposits, the ware produced was very colorful with repetitive, arabesque designs.

The greatest achievement, and indeed the most unique contribution of the Middle Eastern potter, was the development of luster, a form of overglaze decoration in which a thin metallic film is developed on the glaze.

"Luster was used with magnificent effect by the Persian potters of the Middle Ages. The technique was the perfect ceramic vehicle for a culture which had developed a strong, rich, decorative tradition."[1]

Although the first glazes were presumably discovered in Egypt and the Middle East, the greatest technical advancements of ceramic bodies and glazes took place in China. The earliest evidence of Chinese pottery is estimated to date in Prehistoric times, about 3000 B.C..[2] The Shang period, 1766 to 1122 B.C., produced some pottery, but the greatest art of this period was jade carvings and bronze vessels which were used for ritual purposes. It was not until the Han period, which began about 200 B.C., that any evidence of glazes appeared in China. For the first time there is evidence of foreign contacts and exchange which in turn affected the ceramic art.

Two types of glazes are evident in the ware produced in early Han times. According to Rhodes,..."an early type of glaze was formed by the ashes of the fire which were blown through the kiln by the draft of the fire, fell on the ware (if it were unprotected) and formed a glaze on the surface. Some old Chinese pots have a glaze on one side only, as on the shoulder, which can be accounted for by the ashes in the firing chamber."[3] The other early glaze is a lead base type, runny, and usually greenish in color. Since there is evidence of foreign trade at this time, perhaps the appearance of a lead glaze in China could be attributed to an influence of Middle Eastern techniques or possibly to the influence of trade with the

1. Rhodes, Daniel, Clay & Glazes for the Potter, (New York, 1957), P. 83.
2. Gardner, Helen, Art Through the Ages, (New York, 1959), P. 542.
3. Rhodes, Daniel, Clay & Glazes for the Potter, (New York, 1957), P. 58.

Roman Empire.

The greatest contribution of China to the ceramic art was the development of high fire ware—stoneware and porcelain. All pottery produced in the early Roman Empire and the Middle East was of an earthenware type, fired to about 1050°C. or less. In China, however, kiln firings of 1200°C. and more were common perhaps as early as 500 B.C. The Chinese potter..."was more interested in higher fired ware, and by late Han they were producing stoneware jars with a feldspathic glaze fluxed with lime or wood ashes."[1]

Besides the stoneware, the Han potter also produced ware which is believed to be the beginning of porcelain. The discovery of these early proto-porcelain pieces is fairly recent, within the past fifty years. Most examples have a body which is a grey porous substance coated with a white engobe or slip and covered with a fluid greenish-yellow transparent glaze. Although these pieces seem rather crude and heavy, they mark the beginning of a ceramic achievement unequalled in history. The stoneware and porcelain produced during later Sung and Ming periods show an incomparable refinement of form and technical development of bodies and glazes.

The history of ceramics is such a vast subject, that to discuss its development in depth would constitute a study in itself. For this reason, I have been somewhat selective as to the information presented. The periods discussed are not necessarily the greatest in terms of historical significance, but it is hoped they will give the reader a general account of events leading up to the development of stoneware as we know it today.

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1. Nelson, Glenn C., Ceramics, (New York, 1971), P. 8.

# CHAPTER II

# OXIDATION AND REDUCTION COMPARED

In the process of producing pottery, the final step involves the firing of ware to a temperature which vitrifies the clay body and matures the glaze composition. There are basically two types of atmospheres produced in a glaze fire, oxidation and reduction. The reduction fire seems to be preferred by most potters and their preference is not without justification. The subtle color and textural effects obtained in a reducing atmosphere are indeed fascinating and intriging to the potter.

## Reduction Fire

A reduction fire is one in which there is incomplete combustion within the kiln chamber. The atmosphere, being cloudy and smoky, often has a dramatic effect on the clay body and the glaze. When the atmosphere of the kiln is in a state of reduction, the fire is starved for oxygen and will draw it from all available sources. One source is the openings in the kiln, as the burner ports, where the flames will reach out for the needed oxygen. "As a result, the free carbon in the kiln atmosphere unites with, and thus reduces, the oxygen content of the metallic oxides in both the body and the glaze, thereby altering their color."[1] One way this action affects the appearance of the body and the glaze is in the form of specks or "iron spots". Reduced clay bodies also tend to be darker and more textural.

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1. Nelson, Glenn C., Ceramics, (New York, 1971), P. 279.

The color of glazes produced in a reducing fire are affected in several ways: They tend to be more closely related, softer in appearance, and pleasant to the touch. Certain colors are unique to reduced stoneware and porcelain glazes. These are the grey or greenish glazes, known as celadons, and the red colors derived from copper.

## The Oxidation Fire

In a fuel burning kiln, the oxidation fire produces an atmosphere in which there is complete combustion within the kiln chamber. An electric kiln always has an oxidizing atmosphere because there is nothing within the chamber to consume the oxygen. "There is no movement of air or gas through the kiln and the heat is generated in a way which does not affect the atmosphere inside the firing chamber."[1]

Stoneware glazes fired in oxidation have a character of their own. They tend to be a little cooler, colors are brighter, and very often, glazes which are mat in reduction will tend to be more transparent in oxidation. The clay body of ware produced in an oxidizing atmosphere will be lighter in color and will not have the iron spotting as in reduction.

## Electric and Fuel Burning Kilns

In order to produce a reduction atmosphere, one must use a fuel burning kiln. These kinds of kilns are bulky, they must have a chimmey and ventilation system, and they require more skill to operate. Electric kilns are clean, compact, odorless, and because no venting system is required.

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1. Rhodes, Daniel, Stoneware and Porcelain, (New York, 1959), P. 151.

They can be installed just about anywhere. The process of firing an electric kiln is easily mastered.

Since there are so many variables involved in firing a fuel burning kiln, especially reduction firings, it is difficult to achieve identical effects from one firing to the next. This problem is virtually eliminated in an electric kiln as long as the firing temperature remains constant.

The cost of kiln operation is always of concern to the potter. Natural gas is next to oil probably the least expensive material to use for kiln heat, but one must also consider the greater cost involved in building or buying the fuel burning kiln. Electric kilns, although more expensive to operate, have an initial investment which is considerably less than most fuel burning kilns.

## Conclusion

There are advantages and disadvantages in using electric kilns as well as there are in using fuel burning kilns, and choice of kilns has to be based on individual preference and need. For the purpose of this study, however, I have stressed the advantages of the oxidation fire in an electric kiln.

# CHAPTER III

## OXIDATION CLAY BODIES

The experiments which I conducted with clay bodies produced in an electric kiln were not done with the purpose of disproving the process of reduction firing, but rather, to develop oxidized clay bodies which are comparable in terms of color and textural qualities to those produced in reduction.

Since most public schools do not provide a pug mill for use in preparing clay for student use, I decided to use a commercially prepared clay body as a basis for these experiments. The body used is a stoneware composition produced by the Minnesota Clay Company in Minneapolis, Minnesota. The formula for this clay body is as follows:

80 Ball Clay (Kentucky)

25 Stoneware Clay (Cedar Heights)

17 Feldspar (Custer)

10 Flint

10 Yellow Ochre

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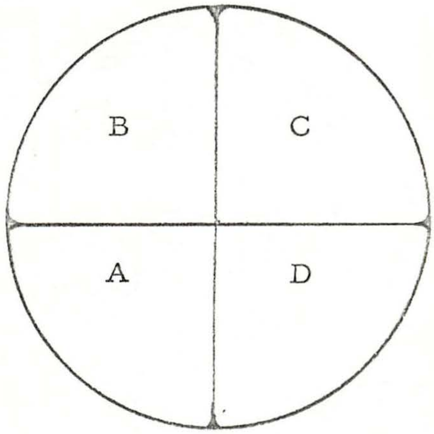
This is a fairly good throwing body, but as with all plastic clays, it has a high shrinkage rate (about 13%0, pieces have a tendency to crack in drying, and certain forms were noted to warp somewhat in the firing process. The addition of about ten percent fine grog greatly reduced these problems and had little or no effect on the plasticity of the body.

The experiments illustrated and described in this chapter were done by adding various materials to five hundred gram batches of the Minnesota

Clay body and firing them in an electric kiln to cone six, 2232°Fahrenheit. All of the test tiles shown are glazed with three different types of glazes, with one-fourth of the tile left unglazed in order to see the effect of the materials on the clay body itself. None of the glazes have additions of coloring oxides or texture producing materials, so any change in surface appearance is a direct result of the materials added to the clay body. All tiles have the glazes placed on them in the order shown in the diagram, (Fig. 1). Formulas for the glazes used on the body tests are provided for the benefit of the reader:




(Fig. 1)

A. <u>Transparent Glaze</u>

63.0 Volcanic Ash
7.0 Kaolin
8.0 Dolomite
20.0 Flint
10.0 Gerstley Borate
3.0 Bentonite

B. <u>Albany Slip Glaze</u>

80.0 Albany Slip Clay
20.0 Whiting
10.0 Cornwall Stone

C. Opaque White Mat Glaze

| | |
|---|---|
| 50.25 | Soda Feldspar |
| 16.80 | Dolomite |
| 6.30 | Barium Carbonate |
| 9.45 | Kaolin |
| 3.15 | Whiting |
| 17.85 | Flint |
| 3.15 | Bentonite |
| 8.50 | Talc |
| 5.00 | Bone Ash |
| 5.00 | Lithium Carbonate |
| 6.30 | Tin Oxide |

D. Unglazed Portion: Whatever materials were added to the body.

It should be noted that any slip clay, such as Albany, is made up of alkaline earth compounds plus iron impurities of varying amounts. The composition, however, will be consistent on each of the tiles.

## COLOR IN OXIDIZED CLAY BODIES

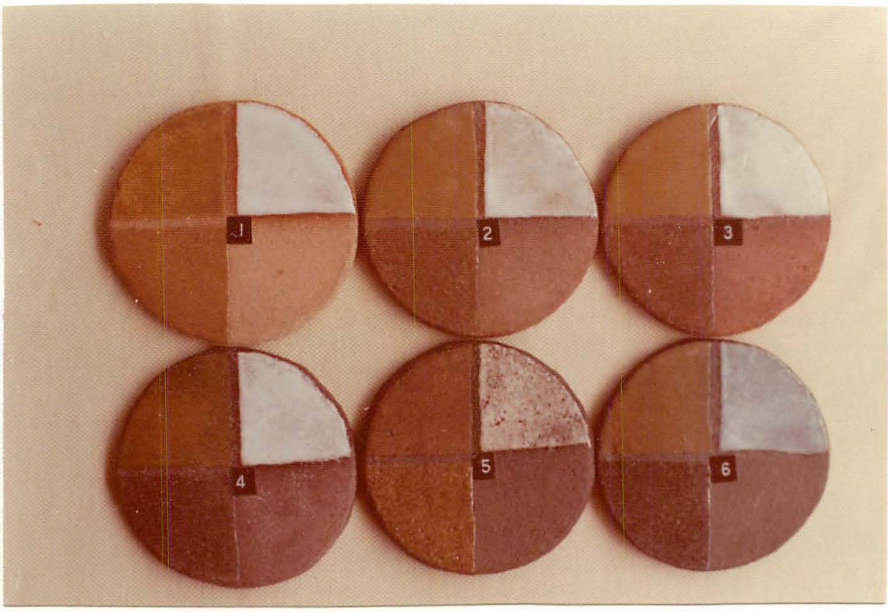
Fired clay bodies may range in color from white to grey, buff, red and dark brown, to black. Although these tones are predominately warm and earthy, I feel they are the most desirable colors for clay bodies. Clay is derived from the earth and the ware produced from it should reflect that quality. For this reason, oxides selected for use in these tests are those that would produce colors similar to the ones mentioned above.

Since the clay body selected for these tests already had ten parts of yellow ochre, an impure form of iron, in its composition, further additions of coloring oxides were limited to not more than five percent. It was felt that any greater amounts could make the body unstable at stoneware temperatures. The coloring oxides used were, red and black iron oxide, iron chromate, manganese dioxide, and a black mixture composed of cobalt, iron, chromium, manganese and nickel.

The tiles shown in figure 2 illustrate the results of these color tests. The color of the regular Minnesota Clay body (Tile 1) is a light buff-color, the glazes are smooth, and there is no distinct textural quality evident on any portion of the tile.

Red Iron Oxide (Tile 2) 5%

The addition of 5% red iron resulted in a warm, brown toned body without any marked increase in texture. A warmer tan tone is apparent in the white glaze; the clear glaze is darker, reflecting the body color; and the Albany glaze becomes only slighty darker in value than on tile 1.




(Fig. 2)

Black Iron Oxide (Tile 3) 3%

A brick-red colored body similar to the color of earthenware was obtained with the addition of 3% of black iron oxide. All three glazes remained pretty much the same as those on tile 2, except for the clear glaze, which became darker in tone, again due to the darker body.

Iron Chromate (Tile 4) 3%

The body color resulting from the addition of 3% iron chromate is a greyish umber. The white glaze becomes cooler in tone and more mat in surface appearance. A cool grey color is evident in the clear glaze, and the Albany glaze changes from a warm greenish tone to more of an olive green, also with a cool cast.

Manganese Dioxide (Tile 5) 5%

Both 3 and 5% additions of manganese dioxide resulted in a chocolate brown colored body. Since there was only a slight difference between them, I have chosen to illustrate the one with 5%. This is a very rich brown body color and the manganese had a pronounced effect on all of the glazes. The clear glaze became a slightly speckled tan, contrasting more with the body than on any of the other tiles. A rich medium brown resulted from the Albany and the white mat glaze became darker in tone with dark brown specks bleeding through from the clay body. All three glazes create a handsome contrast to the body.

Black Mixture (Tile 6) 5%

The addition of 5% of this mixture produced a body which is almost black in color, perhaps very similar to the Basalt ware body developed by the Wedgewood potteries in England during the late eighteenth century. A very cold, almost bluish-white results from the normally warm, white glaze; the albany glaze is a dark olive green. The transparent glaze is almost exactly the color and value of the body, and except for the glossy surface, there is really no contrast to the body.

BODY TEXTURE PRODUCED BY THE ADDITION OF GROGS

A grog is usually made of fire clay or similar material which is fired, ground up, and sifted to obtain different sized particles. These particles, when added to a clay body, give the body more open structure thus facilitating drying and lessening the shrinkage. The percentage of grog and the size of the particles is dependent largely on the process which is being used to shape the ware. Since the body I am concerned with is primarily a throwing body, the percentage used is from 5 to 10%, and the particle size is about forty mesh. If one desired a hand building or sculpture body, the mesh could be large and the percentage of grog should be about 20%.

The addition of grog for this purpose is primarily concerned with the surface or textural quality of the clay body. For this reason, it was desirable to have different colored grogs rather than the commercially produced type which is pretty much the same buff color as the clay body. A dark brown grog was made by adding 5% of manganese dioxide to the clay and pressing it through a strainer. The particles were then bisque fired, ground with a mortar and pestel, and sifted to the desired size. The same process was used to make a white grog using porcelain clay. A reddish colored grog was made by grinding up a common red brick and sifting the particles through a forty mesh seive. These materials were then added to five hundred gram batches of the Minnesota Clay body in amounts of 5 to 10%.

Porcelain Grog (Tile 7) 40 mesh, 10%

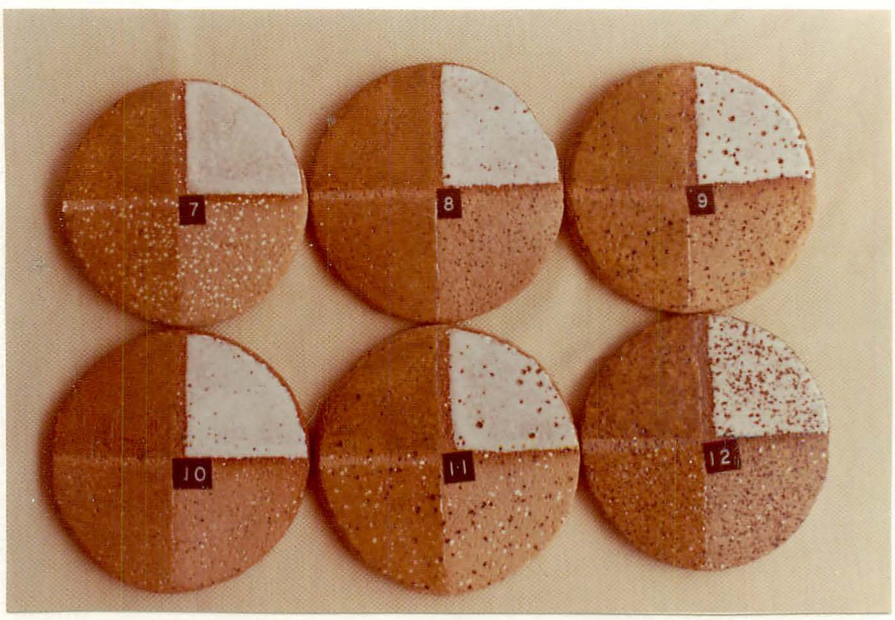
The addition of the white grog produced a pronounced white speckling in the body which was reasily visible through all three glazes, although somewhat less in the white mat. Color and surface feel of the glazes were not affected.

<u>Manganese Grog</u>, (Tile 8) 40 mesh, 5%

A subtle dark speckled body was achieved with the addition of 5% manganese grog. The particles bled through the glazes but were the most evident in the white glaze as different sized dark brown specks.

<u>Red Brick Grog</u>, (Tile 9)40 mesh, 5%

This type of grog produced the most satisfactory results in terms of surface texture in both the clay body and the glazes. Reddish brown specks of varied sizes bled through the surface of the glazes resulting in an "iron spotting" effect quite similar to that which is obtained in a reduction fire. The reaction of this type of grog is more like a granular oxide than a grog.



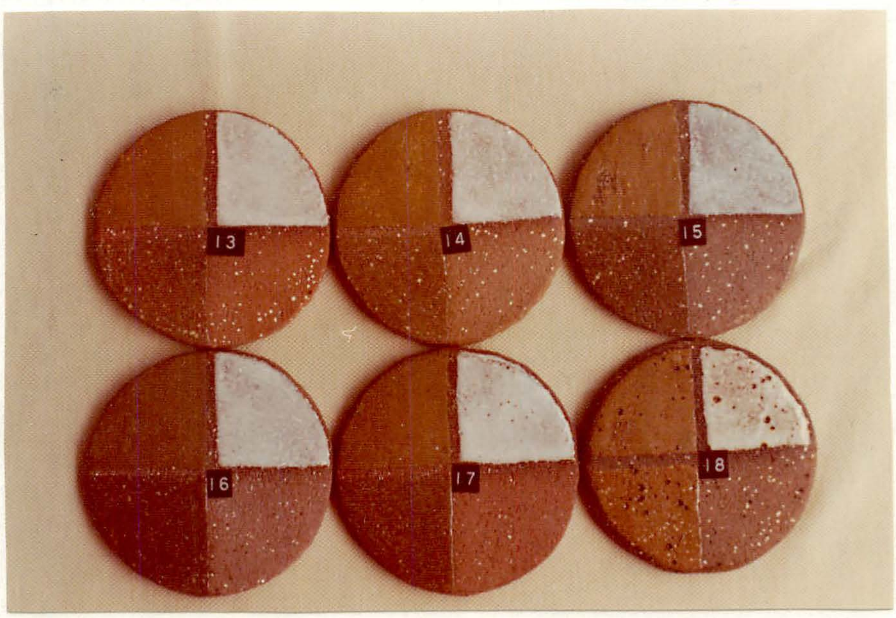

(Fig. 3)

<u>Combinations of Grogs</u> (Tiles 10, 11, 12)

Tile 10, with 3% white and 3% manganese grog, resulted in a body with slight dark and light speckling, having only a moderate effect on the glazes. The addition of 5% porcelain grog and 3% red brick grog gave a "salt and pepper" kind of body with the red brick particles bleeding through the glazes. (Tile 11) Porcelain grog in the amount of 5% along with 2.5% granular manganese produced increased dark speckling resulting in a greater visual effect of texture. (Tile 12) Combinations of colored grogs and granular oxides with different colored clay bodies offer an unlimited range of textural qualities.

COLORED CLAY BODIES AND GROGS COMBINED

The experiments illustrated and described in this section show the effects of light and dark colored grogs combined with the kinds of clay bodies illustrated in Figure 2. The percentage of coloring oxide was reduced so that the darker grogs would not be overwhelmed by the color of the body.




(Fig. 4)

Black Iron Oxide 2%, Porcelain Grog 5%

This combination produced a light reddish brown body with white specks. Little or no change is seen in the glazes except for the specks showing through the transparent glaze. (Tile 13)

Red Iron Oxide, 2%, Porcelain Grog, 5%

A dark tan body with white specks was attained with this combination and the glazes have exactly the same color, texture and surface quality as in tile 13. (Tile 14)

Black Mixture, 3%, Porcelain Grog, 5%

This combination resulted in a grey body color with light colored specks. The white mat glaze is a cool white, the albany glaze becomes more olive green in tone, and the darker body is reflected in the clear glaze with the white grog showing through the surface. (Tile 15)

Iron Chromate, 2%; Porcelain Grog, 3%; Copper Tailings, 2%

Combining these three ingredients produced a light umber body. The porcelain grog is evident, but the copper tailings apparently were not strong enough to make any visual change in the appearance of the body or the glazes. (Tile 16)

Black Iron, 3%; Manganese Grog, 3%; Porcelain Grog, 3%

A dark reddish brown body with slight dark and light speckling was the result of combining these three materials. The dark manganese grog comes through somewhat in the glazes, but would be more evident if used in a lighter colored body such as in tile 13 and 14. (Tile 17)

Manganese Dioxide, 2.5%; Porcelain Grog, 5%; Red Brick Grog, 5%

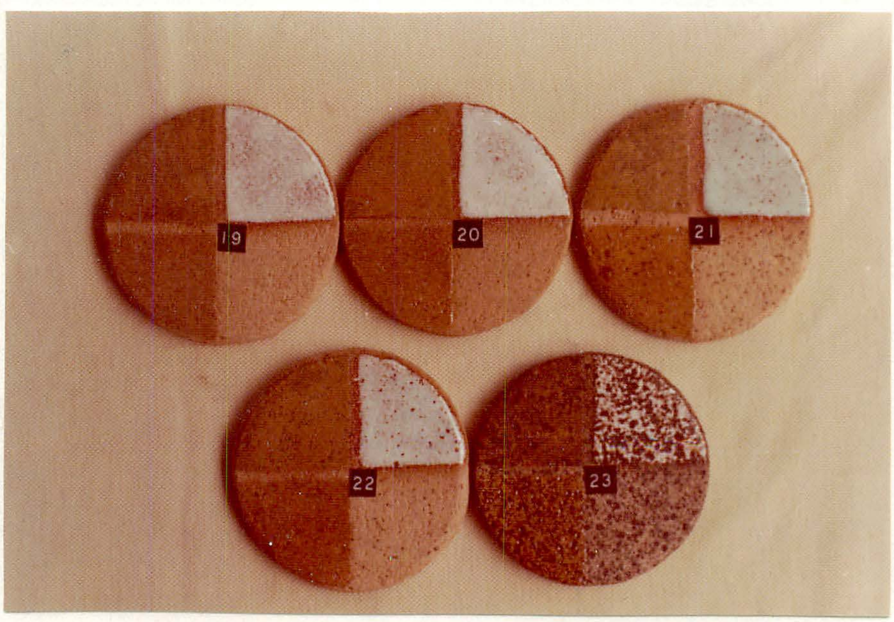
The result produced by this combination of materials was to me the most pleasing of all. The body color is a warm grey-brown with dark and light speckling, and the glazes look more a part of the body due to the red brick particles bleeding through the surface. Here again, due to fusible particles, the kinds of ware produced with a body of this type would have to be restricted to those which are more decorative than functional. (Tile 18)

BODY TEXTURE PRODUCED BY GRANULAR METALLIC OXIDES

The granular metallic materials added to the basic clay body were granular manganese, illmenite, taconite tailings and copper tailings. All of these materials were available in the ceramic studio for immediate use. The copper tailings, however, had to be ground and sieved to obtain a mesh size suitable for adding to a throwing body. It should be noted that ware produced with these kinds of materials in the body should be limited to pieces not requiring a cover, as the particles will melt and fuse the cover to the pot.

Illmenite and Taconite Tailings, 5%

The addition of 5% illmenite and taconite tailings produced very




(Fig. 5)

little textural effect on the body, the only noticeable difference being a slightly darker body color from the illmenite. (Tile 20) Glazes remained pretty much unchanged except for a very slight speckling which was more evident in the white mat. (Tiles 19 and 20)

Copper Tailings 5%

A more definite textural appearance was achieved by the addition of 5% taconite tailings, perhaps due to the large size of the particles. Of particular interest in the glazes was the change in the color of the white mat, which became a very light turquoise with specks. (Tile 21) A combination of copper and taconite tailings totaling 5% gave somewhat the same results as the copper alone. (Tile 22)

Granular Manganese, 5%

Of the metallic oxides, granular manganese created by far the greatest textural reaction in both the body and the glazes. Five percent of this material produced black and brown, granite-like surface on the clay body. The same extreme texture is evident in the glazes, with the white mat becoming almost eveningly mottled between dark brown and white. Although the glazes have a visual appearance of being rough in texture, they are actually quite smooth to the touch. (Tile 23) This kind of surface would be quite handsome for decorative ware, but since the surface is so texturally busy, one would have to be quite selective in the kinds of shapes used. It would be very handsome on large, rather simplified bottle forms, or perhaps on large bowls and plates.

## CHAPTER IV

## CONE SIX OXIDATION GLAZES

It has been my experience in the past to prefer the glaze effects obtained in a reduction fire to those produced in oxidation. Glazes fired in an oxidizing atmosphere tend to be shinier, usually more transparent, and are for some reason lacking in surface quality. The experiments which I conducted with glazes in an electric kiln were aimed primarily toward developing surface qualities which had textural or color breaking effects.

All glaze tests were either dipped or brushed on tiles made from the regular Minnesota Clay body. In some cases, the tiles were thrown on the wheel so as to see the effect of the glaze on pronounced throwing rings. Coloring oxides used in the glazes are determined more or less by personal preference rather than any systematic procedure, with the exception of those which were known to produce textural or breaking surfaces. All tiles were placed vertically in the kiln and fired to cone six $2232^{o}$ Fahrenheit. The best results were obtained when the kiln was soaked for about 20 to 30 minutes when the six cone bent down. This seemed to eliminate the tendency for pin-holing in some of the glazes.

### TEXTURAL SURFACES FROM GRANULAR OXIDES

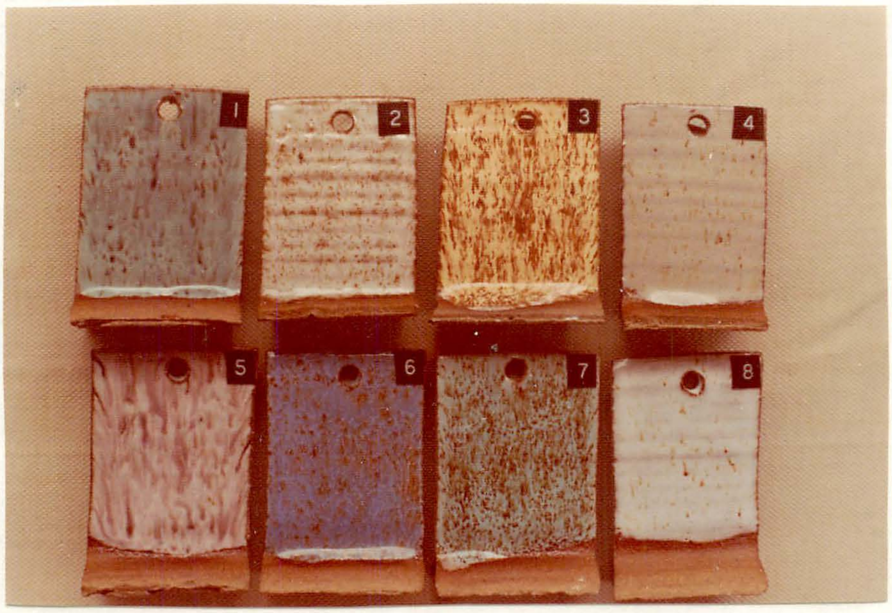
The base glaze used for these tests is the same one which was used on one section of the body test tiles, the opaque white mat. (Formula on p. 11) The percentage of granular oxides is the same in each test (2%) with the percentage of other colorants determined pretty much by personal preference and past experience in their use.

Granular Manganese, 2%

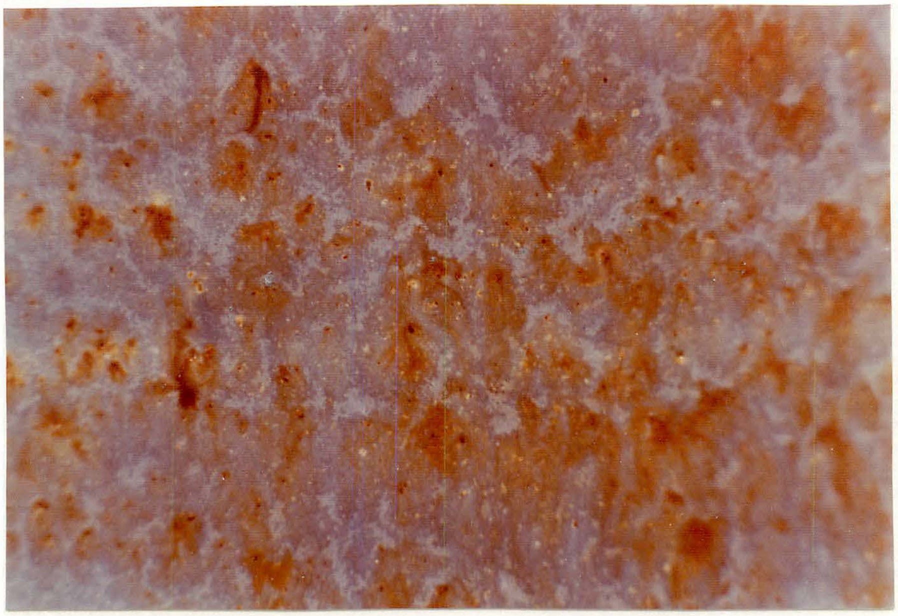
The addition of 2% granular manganese and 1% copper produced a light turquoise color with dark brown and greyish streaks breaking through the surface. (Tile 1) With the addition of the granular manganese alone, the appearance was off-white with streaks of purplish brown. (Tile 5)

Illmenite, 2%

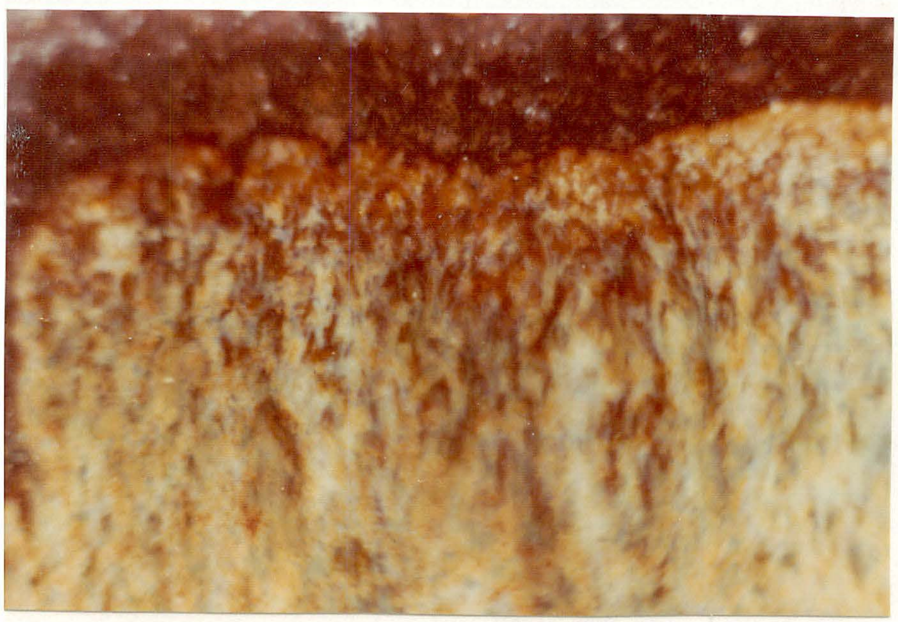
Illmenite developed more of a speckled quality rather than the streaks produced by granular manganese. When combined with 3% vanaduim oxide, a warm off-white with gold specks resulted. (Tile 2) A breaking light blue with tan streaks and specks was obtained by the addition of .5% cobalt oxide and illmenite. (Tile 6) The cobalt apparently made the glaze more fluid and developed a glossier surface. A surface detail of tile 6 is shown in Fig. 7.




(Fig. 6)



(Fig. 7)
Surface detail of Tile 6



(Fig. 8)
Surface detail of Tile 13

Taconite Tailings, 2%

This material produced the most pronounced textural effect of the granular oxides. When combined with 1% copper oxide, a turquoise blue with warm brown specks and streaks resulted. This is a warmer turquoise than shown on tile 1. (Tile 7) When combined with 5% rutile, the taconite became more fluid and streaked causing the glaze to settle in a soft roll at the base of the tile. (Tile 3)

Copper Tailings, 2%

When added to the base glaze without other colorants, the glaze is a soft white mat with very subtle tan specks and streaks coming to the surface. (Tile 8) The combination of 3% nickel oxide and 2% copper tailings produced a light toned grey-green color with slight tan streaks (Tile 4). The surface of this glaze became less glossy, more of a semi-mat.

All of these glazes have a smooth surface, ranging from very glossy to semi-mat and they would be exceptionally suited for use on functional ware.

## OVERLAPPING GLAZES FOR VARIED SURFACES

Some extremely subtle and varied surfaces can be obtained by applying one coat of a fluid glaze and covering it with another layer of a stiff glaze. The fluid glaze breaks through the surface of the second coat causing some unusual mottled and streaked effects. Reversing this process also produces similar results, but most of the examples shown have the fluid glaze applied first and are covered with a coat of stone mat magnesia glaze. When glazing ware with this process, it works best to have a sufficient amount of glaze so as the piece can be coated by either pouring or dipping. If there is a great time lapse between successive coatings, the second coating has a tendency to chip off in drying.

<u>Tile No. 9</u> (Fig. 9)

This extremely mottled black, grey and white surface was achieved by covering a fluid black glaze with the magnesia mat glaze. The surface is smooth, semi-mat, and has buttery feeling to the touch.

<u>Tile No. 10</u> (Fig. 9)

Some subtle color and texture was produced in this test by coating the leather-hard tile with Barnard clay slip and over-glazing with the magnesia mat glaze. Here again, the surface is semi-mat and smooth.

<u>Tile No. 11</u> (Fig. 9)

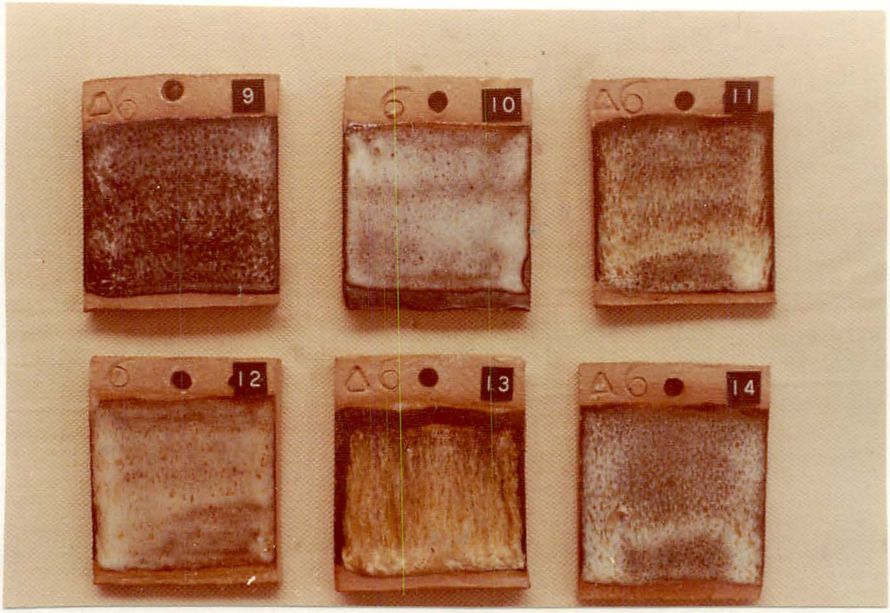
A breaking reddish brown, tan to white resulted when a high iron content slip glaze was covered with the magnesia glaze. This slip glaze was made from a local clay deposit, with 10% red iron oxide added to the base. The surface of this glaze is smooth, but is much shinier due to the high iron content.

<u>Tile No. 12</u> (Fig. 9)

An off-white with orange-red specks is the result on this tile when a fluid glaze containing 10% yellow ochre is covered with the magnesia glaze. The surface is smooth and shiny.

<u>Tile No. 13</u> (Fig. 9)

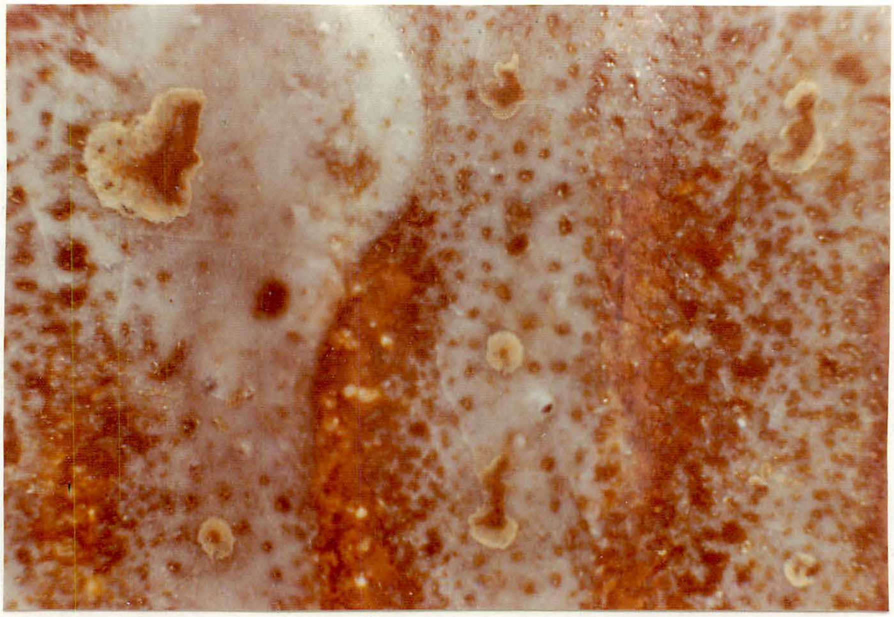
Breaking gold to brown tones were obtained when a fluid Barnard slip glaze was covered with the magnesia glaze. The glaze is somewhat active, but is smooth and semi-mat. A surface detail of this glaze is shown in fig. 8.



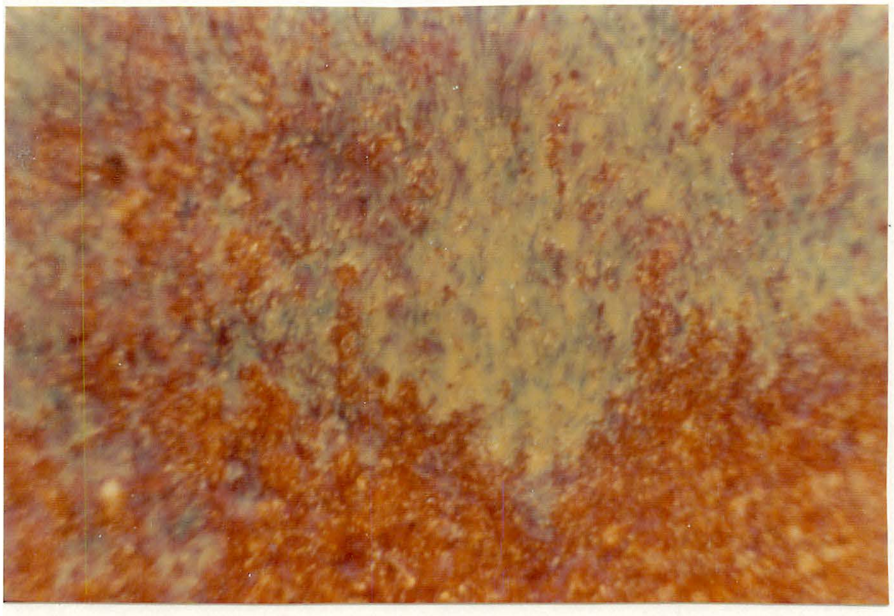

(Fig. 9)

<u>Tile</u> <u>No.</u> <u>14</u> (Fig. 9)

A particularly nice, almost "oil spotting" effect was achieved by covering the local slip glaze with the magnesia glaze. The spots are grey-green to brown and the surface is smooth with a semi-gloss.



(Fig. 10)
Surface detail of Tile 18



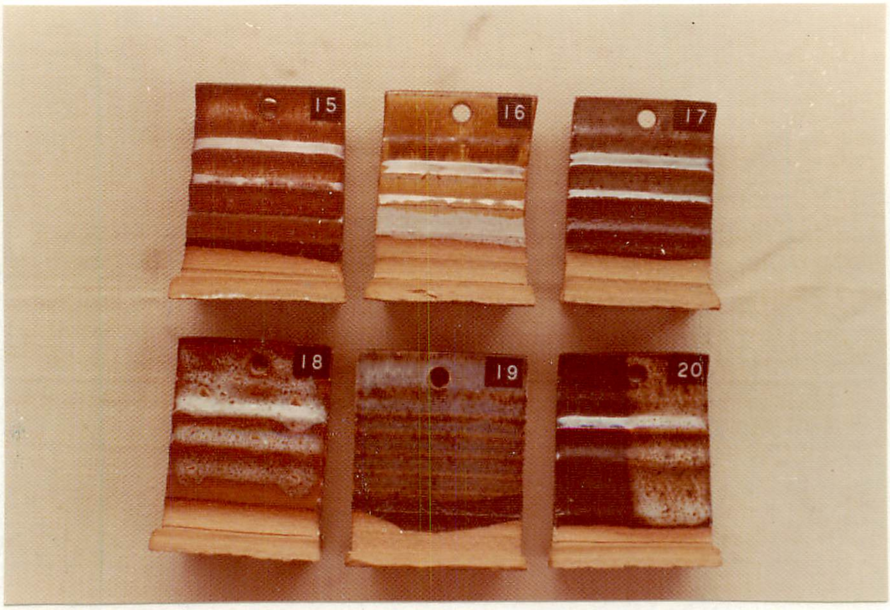
(Fig. 11)
Surface detail of Tile 25

Tile No. 15 (Fig. 12)

This combination of glazes (the opaque white mat used on the body tests, over the local slip glaze) produced a breaking orangish red to brown which has a sort of "hairs fur" effect.

Tile No. 16 (Fig. 12)

In this test, the more fluid glaze with a high content of crocus martis yellow overlaps the opaque white mat glaze. The result is breaking yellow-gold to light brown tones, and the surface is smooth and very glossy.




(Fig. 12)

Tile No. 17 (Fig. 12)

A grey-green with dark spotting is the effect resulting from this combination. The first coat is a saturated iron glaze; the second is a magnesia glaze containing cobalt and nickel oxide.

Tile No. 18 (Fig. 12)

An extremely interesting surface of breaking gold almost "fish eye" effects resulted by covering a crocus martis glaze with the magnesia glaze. The throwing rings of the tile cause the glaze to pool and break, adding to the varied surface appearance. A surface detail of this glaze is shown in fig. 10.

Tile No. 19 (Fig. 12)

A rutile, cobalt glaze covering a Barnard slip glaze produced a light blue breaking to brown and tan at the throwing rings. The surface varies from mat to semi-gloss, but is smooth to the touch.

Tile No. 20 (Fig. 12)

The Barnard slip glaze containing cobalt and copper gives an extremely mottled white, brown and gold semi-mat surface when covered with the magnesia glaze.

## BREAKING SURFACES FROM SLIP CLAY GLAZES

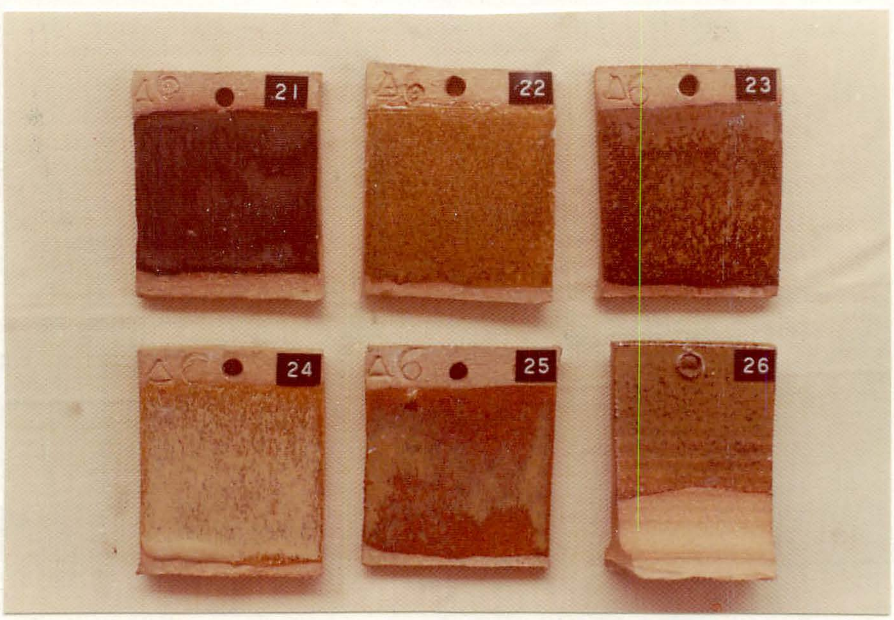
Some very nice textural surfaces result from the use of natural slip clays, which due to their chemical make-up will produce breaking qualities when used as a glaze. Glazes made from slip clays are easy to apply, have a wide firing range, yield colors which are earthy in quality, and react pretty much the same in oxidization as they do in reduction. The only difference being a greater amount of green tones from reduction due to the varied iron content of the clays. The slip clays used in these tests are Albany, Barnard, Wrenshall, and the locally dug clay which I shall refer to as Malner.

Albany Slip Glazes (Tile 22, 24, and 25)

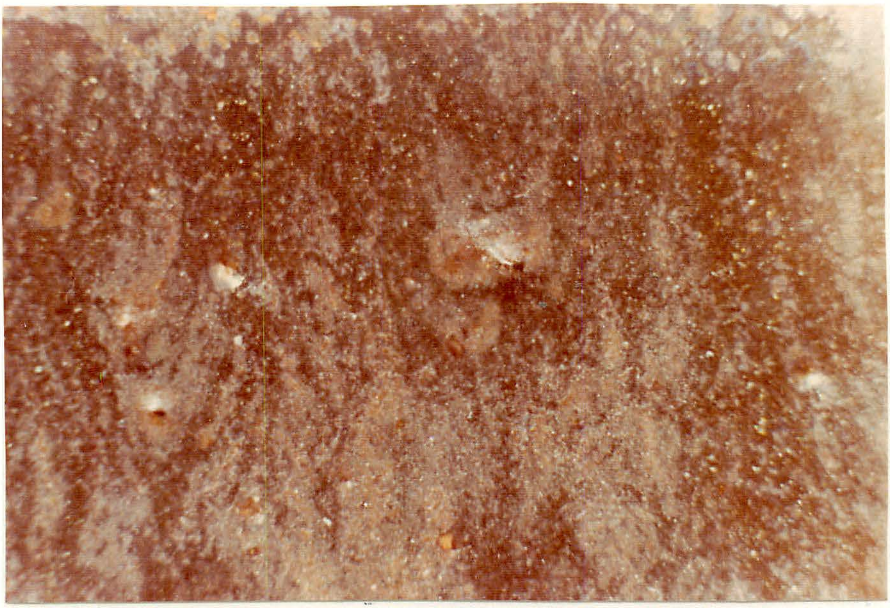
A textural green-brown surface results from the Albany slip fluxed with 20% whiting. (Tile 22) The surface is smooth and semi-mat. With the addition of 5% rutile, the glaze becomes a breaking gold color and more mat in appearance. (Tile 24) An extremely varied surface of gold, green and transparent orange-brown results when cornwall, rutile and crocus martis red is added to the basic Albany-whiting composition. (Tile 25) A surface detail of tile 25 is shown in Fig. 11.

<u>Wrenshall Slip Glaze</u> (Tile 26)

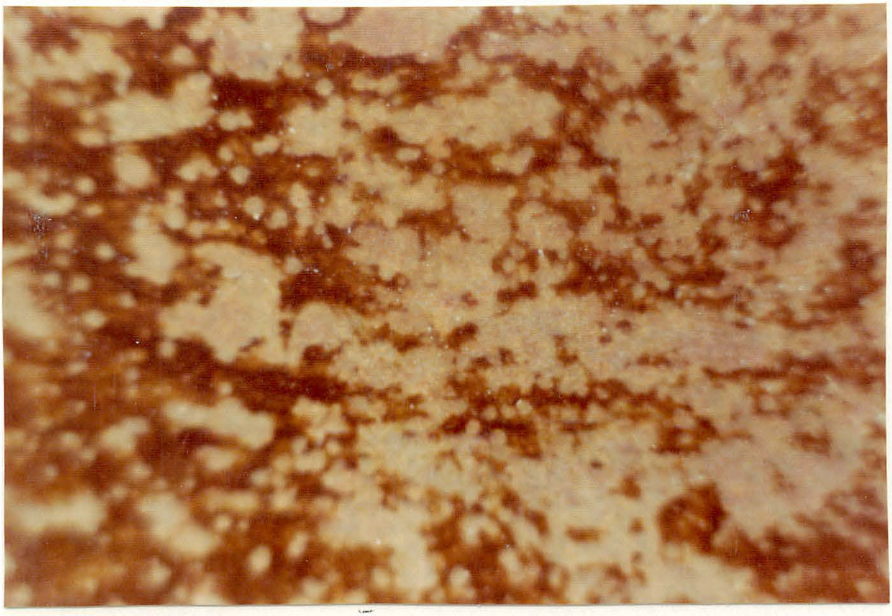
An olive green with breaking brown specks is obtained by adding 20% whiting to the Wrenshall clay. The surface is varied depending on the thickness of the glaze, but is smooth and semi-mat in appearance.




(Fig. 13)



(Fig. 14)
Surface detail of Tile 21



(Fig. 15)
Surface detail of Tile [illegible]

Barnard Slip Clay (Tile 21)

This glaze, which combines Barnard clay, wood ash and lithium carbonate, yields a breaking brown to black, fluid glaze. This is an excellent glaze for combining over or under other glazes. The wood ash and lithium carbonate add to the variable surface of the glaze. A surface detail is shown in Fig. 14.

Malner Slip Clay (Tile 23)

This local clay, which apparently is high in iron content, produced a very mottled surface of gold and brown when fluxed with nepheline syenite, whiting, bone ash and lithium carbonate. The glaze is quite fluid, and the surface varies from mat to gloss depending on the thickness of application. A surface detail of this glaze is shown in Fig. 15.

## VARIED SURFACES DUE TO GLAZE COMPOSITION

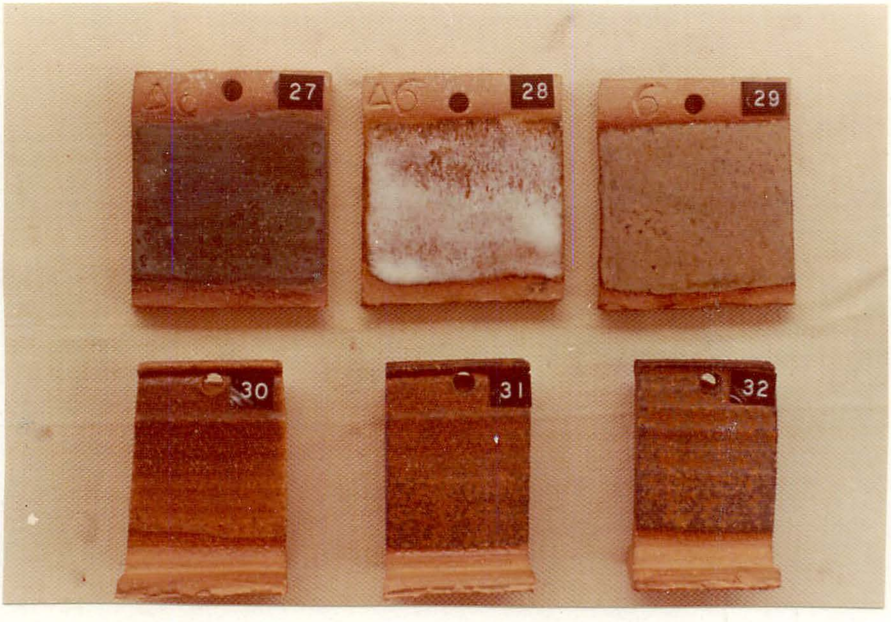
Some varied glaze surfaces were developed by experimenting with different materials as fluxing agents. Besides the textural surfaces, these glazes yield some unusual color effects which cannot be obtained from the more commonly used fluxes. The chemicals used for these tests were barium carbonate, lithium carbonate, wood ash, and fluorspar. The examples of the test results are illustrated in Fig. 16, tiles 27 to 32.

Barium Carbonate Glaze

A soda feldspar glaze with about 25% barium carbonate, borax, and copper carbonate produced a cratered looking surface of blue-green with dark spots. The glaze has a mat quality, and although it appears rather rough, the feel is actually quite smooth. (Tile 27) Surface detail shown in Fig. 17.

## Fluorspar Glazes

Fluorspar combined with lepidolite, with 5% yellow ochre for color, produced a textured brown mat glaze (Tile 30). When the yellow ochre was increased to 10% and combined with 2% iron, a rust brown breaking to black resulted. (Tile 31) The addition of 5% tin oxide to the glaze on tile 31 yielded a breaking yellow to black surface. (Tile 32) It should be noted that this glaze achieves a greater breaking quality when applied thinly. Surface detail of Tile 32 shown in Fig. 18.

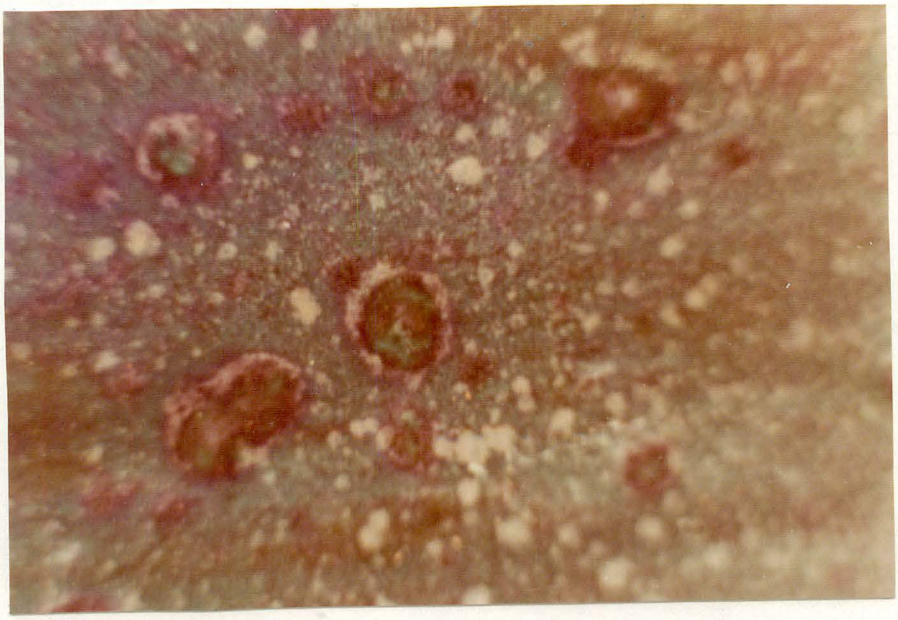



(Fig. 16)

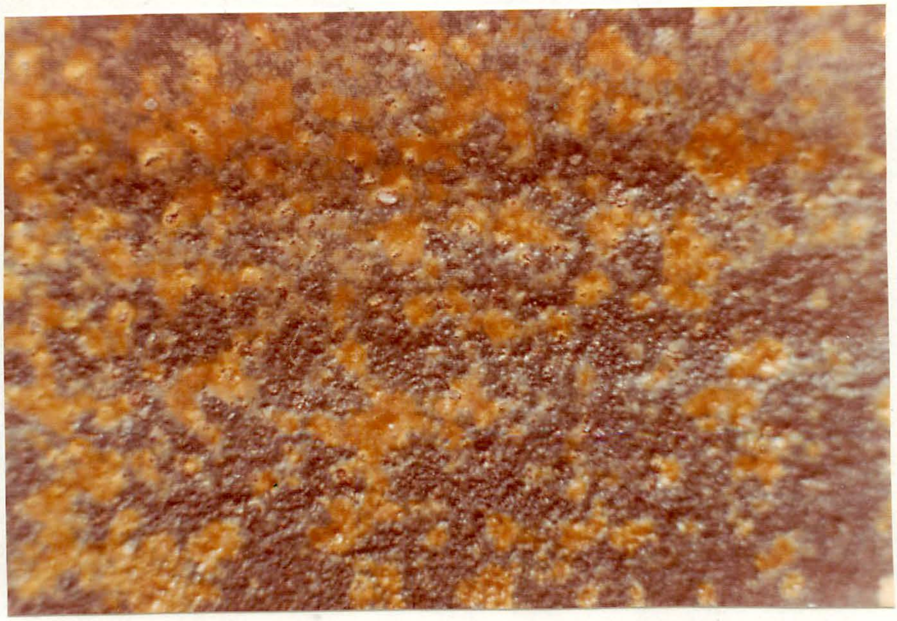
## Wood Ash Glaze

An interesting grey-green textured surface resulted from the combination of wood ash with a mixture of spodumene, flux and clay. (Tile 29)

The surface is of a mat quality and smooth to the touch. Further experiments with coloring oxides should yield interesting results with this glaze.

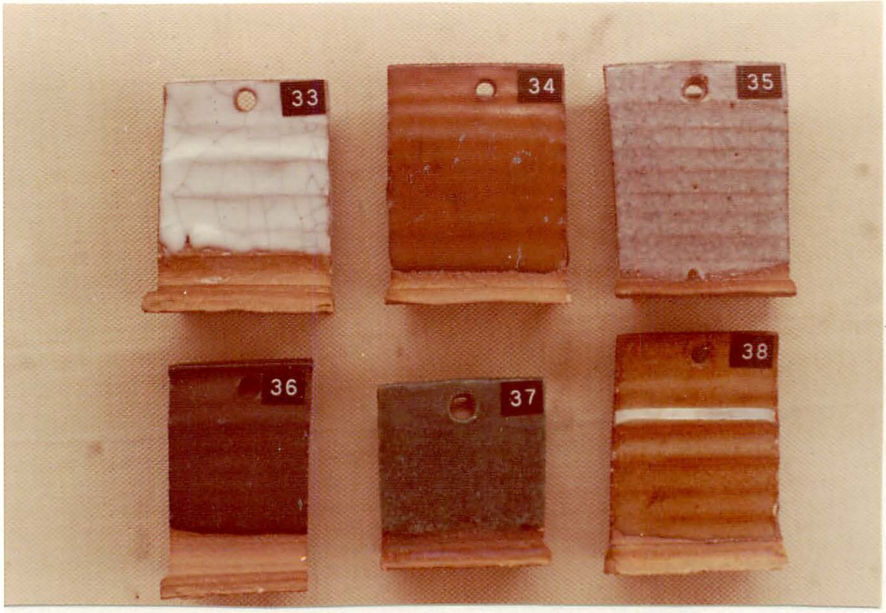


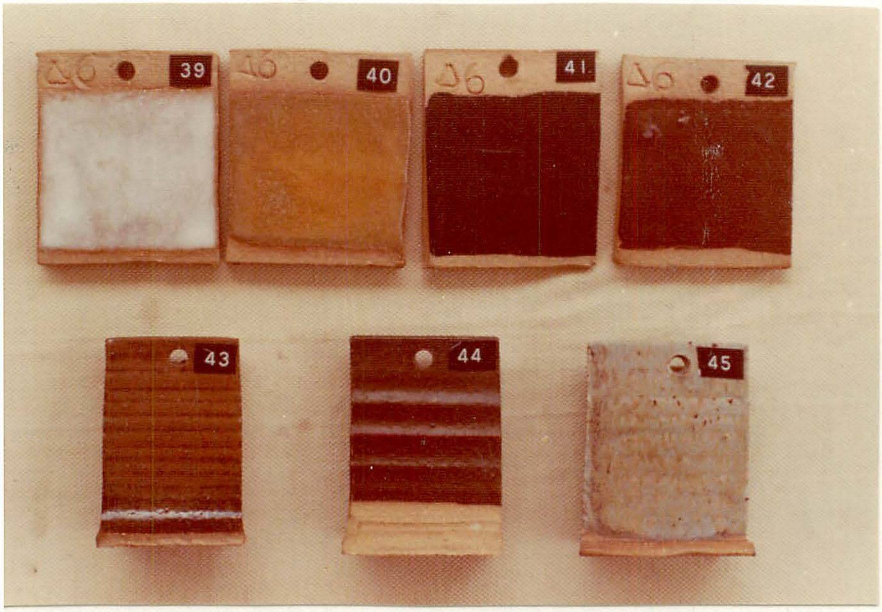
(Fig. 17)
Surface detail of Tile 27



(Fig. 18)
Surface detail of Tile 32

The next two illustrations of glaze samples (Tiles 33 through 44) are some of the basic glazes used in this study which might be of interest to anyone working with cone six oxidation glazes. The formulas for these, as well as all the other glazes discussed previously, are listed according to their tile numbers on P. 38 of this paper. I believe they offer a variety of surfaces and colors which would be a good basis for further experimentation or for setting up a ceramic program in a public school system.




(Fig. 19)

The examples illustrated in Figures 20, 21, and 22 are pieces made using some of the techniques described in this paper. All are made from the commercial Minnesota Clay body and fired in an electric kiln to cone six, 2232° Fahrenheit. The glazes and clay bodies are from the ones presented in this study.

(Fig. 20)

(Fig. 21)

(Fig. 22)

# CHAPTER V

# CONCLUSION

Experimenting with oxidation clay bodies and glazes has been a valuable experience for me. The tests conducted with clay bodies and glazes produced a large number of acceptable results which will be of great value for me as an instructor in the public schools. These tests and results are generally of a basic nature, and in no way set limitations for further experimentation with oxidizing techniques.

It should be noted in concluding, that the solving of technical problems as presented in this report are in no way a guarantee of producing pottery which is of high aesthetic quality. The development of acceptable clay bodies and visually pleasing glazes are virtually useless without the ability to produce forms which have a beauty and vitality of their own. The most beautiful of glazes will not bring to life a dull, inexpressive form — these are only objects for display of an individual's decorative virtuosity. To achieve a truly creative statement in this media, one cannot separate skill and technique from meaning and form.

## GLAZE FORMULAS FOR TILES ILLUSTRATED

1. 50.25 Soda Feldspar
   16.80 Dolomite
   6.30 Barium Carbonate
   9.45 Kaolin
   3.15 Whiting
   17.85 Flint
   3.15 Bentonite
   8.50 Talc
   5.00 Bone Ash
   5.00 Lithium Carbonate
   6.30 Tin Oxide

   Add: 2% Granular Manganese
   1% Copper Oxide

2. Base from No. 1.
   add: 2% Illmenite
   3% Vanadium Oxide

3. Base from No. 1.
   add: 2% Taconite tailings
   5% Rutile

4. Base from No. 1.
   add: 2% Copper tailings
   3% Nickel Oxide

5. Base from No. 1.
   add: 2% Granular Manganese

6. Base from No. 1
   add: 2% Illmenite
   .5% Cobalt Oxide

7. Base from No. 1.
   add: 2% Taconite Tailings
   1% Copper Oxide

8. Base from No. 1.
   add: 2% Copper Tailings

9. Glaze No. 39 over Glaze No. 41.

10. Glaze No. 39 over Barnard Slip.

11. Glaze No. 39 over glaze No. 23 with 10% Iron Oxide.

12. Glaze No. 39 over Glaze No. 42.

13. Glaze No. 39 over Glaze No. 21.

14. Glaze No. 39 over Glaze No. 23.

15. Base Glaze No. 1 over Glaze No. 43.

16. Glaze No. 34 over Base Glaze No. 1.

17. Glaze No. 39 with .5% Cobalt and 1% Nickel over Glaze No. 44.

18. Glaze No. 39 over Glaze No. 34.

19. Glaze No. 45 over Glaze No. 21.

20. Glaze No. 39 over Glaze No. 21 with .5% Cobalt and 1% Copper added.

21. 45.0 Barnard Clay
    45.0 Wood Ash
    10.0 Lithium Carbonate

22. 80.0 Albany Clay
    20.0 Whiting

23. 70.0 Malner Clay
    20.0 Nepheline Syenite
    5.0 Whiting
    5.0 Bone Ash
    5.0 Lithium Carbonate

24. 80.0 Albany Clay
    20.0 Whiting
    5.0 Rutile

25. 80.0 Albany Clay
    20.0 Whiting
    10.0 Cornwall Stone
    5.0 Rutile
    3.0 Red Crocus Martis

26. 80.0 Wrenshall Clay
    20.0 Whiting

27. 28.0 Soda Feldspar
10.0 Barium Carbonate
2.0 Borax
2.5 Copper Carbonate

28. Glaze No. 39 over Glaze No. 29.

29. 84.0 Spodumene
5.0 Lithium Carbonate
3.0 Bentonite
3.0 Gerstley Borate
5.0 Ball Clay
100.0 Wood Ash

30. 64.5 Lepidolite
32. 5 Fluorspar
2.0 Bentonite
5.0 Yellow Ochre

31. 64.5 Lepidolite
32.5 Fluorspar
2.0 Bentonite
10.0 Yellow Ochre
2.0 Red Iron Oxide

32. Same as No. 31, but add:
5.0 Tin Oxide

33. Cornwall Crackle Glaze
85.0 Cornwall Stone
15.0 Whiting

34. Orange-Brown Mat Glaze
Base from No. 1, add:
10.0 Crocus Martis Yellow
2.0 Red Iron Oxide

35. Orange Glaze
18.8 Lepidolite
43.4 Potash Feldspar
6.3 Cryolite
10.0 Bone Ash
15.0 Whiting
12.6 Gerstley Borate

36. Black Mat Glaze
20.0 Barium Carbonate
40.0 Potash Feldspar
20.0 Ball Clay
20.0 Cornwall Stone
20.0 Whiting
3.0 Gerstley Borate
8.6 Black Mixture
(Formula No. 46)

37. Blue-Green Barium Mat
56.0 Soda Feldspar
20.0 Barium Carbonate
4.0 Borax
5.0 Copper Carbonate
2.0 Tin Oxide

38. Glossy Tan Glaze
Base from No. 1, add:
5% Crocus Martis
2% Red Iron Oxide

39. Magnesia Mat Glaze
45.0 Potash Feldspar
20.0 Gerstley Borate
7.0 Dolomite
15.0 Talc
5.0 Kaolin
20.0 Flint

40. Gold Mat Glaze
Base from No. 36 add:
2% Rutile
4% Red Iron Oxide

41. Shiny Black Glaze
70.0 Albany Clay
20.0 Cornwall Stone
5.0 Whiting
5.0 Bone Ash
7.0 Black Mixture

42. Dark Red Brown Glaze
65.0 Feldspar
20.0 Whiting
5.0 Kaolin
3.0 Magnesium Carbonate
10.0 Bone Ash
10.0 Gerstley Borate
8.0 Flint
10.0 Tin Oxide
2.0 Iron Oxide
10.0 Yellow Ochre

43. Brown Slip Glaze
70.0 Malner Clay
20.0 Nepheline Syenite
5.0 Bone Ash
5.0 Whiting
5.0 Lithium Carbonate

44. Chocolate Brown Mat
70.0 Potash Feldspar
20.0 Whiting
10.0 Kaolin
5.0 Spodumene
2.0 Tin Oxide
10.0 Bone Ash
15.0 Red Iron Oxide

45. Breaking Light Blue Mat
Base from No. 36, add:
2.0 Granular Manganese
4.0 Rutile
.5 Cobalt Oxide

46. Black Mixture Formula
31.0 Cobalt Oxide
7.0 Chromium Oxide
37.0 Red Iron Oxide
12.0 Manganese Dioxide
13.0 Nickel Oxide
100.00
(Use about 7% for Black Color)

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